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domain reflectometer**

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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by Optoelectronic Industry and Technology Development Association (OITDA)/Japanese Standards Association (JSA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14.

Consequently **JIS C 6185:1995** is replaced with this Standard.

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Test methods of optical time domain reflectometer

Introduction

This Japanese Industrial Standard specifies the test method of the optical time domain reflectometer, and thereby aims at the stabilization and unification of the relevant tests performed.

This Standard was established in 1995. Since its establishment, the relevant International Standard **IEC 61746** [**JIS C 6185-2**:2007 [Calibration of optical time-domain reflectometers (OTDR)]] has been published. The revision at this time is for making the provisions in alignment with the relevant International Standard.

1 Scope

This Standard specifies the test methods of optical time domain reflectometer (hereafter referred to as “OTDR”) which measures the back scattered light produced by an optical pulse incident to an optical fiber, in a time domain.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

- JIS C 1002 *Glossary of terms used in electronic measuring apparatus*
- JIS C 6182 *Test methods of optical power meters for laser beam*
- JIS C 6183 *Test methods of fiber-optic spectrum analyzer*
- JIS C 6710 *Generic specification of crystal controlled oscillators*
- JIS C 6802 *Safety of laser products*
- JIS C 6823 *Measuring methods for attenuation of optical fibers*
- JIS C 6832 *Silica glass multimode optical fibers*
- JIS C 6835 *Silica glass single-mode optical fiber*
- JIS C 60068-2-6 *Environmental testing Part 2: Tests—Test Fc: Vibration (sinusoidal)*
- JIS C 60068-2-31 *Environmental testing Part 2: Tests. Test Ec: Drop and topple, primarily for equipment-type specimens*
- JIS Z 8103 *Glossary of terms used in measurement*
- JIS Z 8120 *Glossary of optical terms*

3 Terms and definitions

For the purpose of this Standard, the terms and definitions specified in **JIS C 1002**, **JIS Z 8103** and **JIS Z 8120**, and the following principal definitions apply.

3.1 OTDR

an optical measuring apparatus which has a function to measure the fault point or loss of an optical fiber in such a manner that an optical pulse is introduced into an optical fiber, and the intensities of Fresnel reflected light and back scattered light of optical fiber produced by the optical pulse are measured in a time domain at the incident end, with the results indicated on the picture plane

3.2 Fresnel reflected light

the reflected light produced when the light passes through a boundary surface of substances having different refractive index

When an optical connector and/or the end surface of an optical fiber cut neatly enough are placed in air, about 4 % of the light incident to the end surface is reflected.

3.3 back scattered light

the light which returns in the direction reverse to the propagation direction of incident light (to incident side) from the scattering source when the light is introduced into an optical fiber

3.4 distance range

the distance which can be indicated on the picture plane of an OTDR

The maximum one is called the maximum distance range. In general, actually measurable distance is smaller than the maximum distance range. Strictly, it differs depending on the value of group refractive index of the optical fiber, but it is represented by the value of distance when the value of group refractive index is assumed 1.500 0 for convenience.

3.5 dynamic range

the range where the measurement of intensity of back scattered light is possible

It is expressed by the value of optical fiber loss (value in dB). It may be expressed by the difference between the intersection point of the extension line of back scattered waveform with the optical power axis and the noise level.

3.6 dead zone

the distance range in which it becomes impossible to measure the location of the succeeding reflection point, fusion point, joint, etc., loss, reflectance, etc. due to the reflected light produced at the reflection point of the optical connector, etc. and the spread of received waveform in its bottom caused by the said reflected light

There are two dead zones, i.e. "reflection measurement dead zone" which is the distance range where it becomes impossible to identify the succeeding reflection point from the reflection point and to measure reflectance, and "loss measurement dead zone" which is the distance range where it becomes impossible to measure the loss of other joints or optical fiber. The dead zones in the mouth is called "reflection measurement dead zone in the mouth" and "loss measurement dead zone in the mouth", respectively.

3.7 space resolving power

the shortest distance at which it becomes possible to separate and identify another, different reflection point, fusion point, joint, etc. from the reflection point, fusion point, joint, etc. of optical fiber or to measure the loss of optical fiber

In the case where it is specified by the spread in the bottom of the waveform at the reflectionless joint with optical fiber, it is “space resolving power just behind reflectionless joint” and only “loss measurement space resolving power” which is the shortest distance at which it becomes possible to measure the loss of optical fiber is defined.

4 Standard test conditions

Unless otherwise specified, the conditions employed as the standard for testing OTDR (OTDR to be subjected to test is hereafter referred to as “specimen”) shall be as stated below.

If it is difficult to carry out the tests under the standard conditions for testing, the conditions employed and the effect caused by the change of condition shall be recorded in the test report.

- a) **Temperature** $23\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$
- b) **Relative humidity** $(65 \pm 10)\%$
- c) **Optical fiber** If not specified, the optical fiber shown in table 1 corresponding to the classification of specimen shall be used.

The symbols in the table are those specified in **JIS C 6832** or **JIS C 6835**.

Table 1 Optical fiber to be used in test

Classification of specimen		Optical fiber to be used in test
Classification of applicable optical fiber	Wavelength of optical source nm	
Multimode optical fiber	850	SGI-50/125
	1 310	
Single-mode optical fiber	1 310	SSMA-9/125, SSMA-9.5/125, SSMA-10/125
	1 550	SSMA-9/125, SSMA-9.5/125, SSMA-10/125, SSMA-8/125

5 Outline of tests

5.1 Classification of tests

The performances of specimen shall be evaluated by carrying out the tests for dead zone and space revolving power distance accuracy, loss accuracy, reflectance accuracy, and further, optical pulse width, optical output level, center wavelength, spectral width, dynamic range. However, the errors obtained by these tests are treated as the evaluation value on each test item and not treated as the overall error by

adding these errors, since the evaluation item in each test differs from that of other test in dimensions. For OTDRs without function for measuring reflectivity, the test for reflectivity need not be carried out.

5.2 Method for calculation of accuracy

The accuracy of measurement of specimen shall be evaluated on the distance accuracy, loss accuracy and reflectance accuracy. The evaluation method is such that the intrinsic error is obtained by the intrinsic error test under the standard conditions for testing, and then the partial error of specimen is obtained by each partial error test. Each error is obtained in percent (%), the limits of operating error are calculated by formulae (1) and (2), and are taken as the accuracy of specimen.

Formulae (1) and (2) are the valuation formulae specified in **JIS C 6182** and **JIS C 6183**.

$$\varepsilon_{tu} = \bar{\varepsilon}_{to} + \sum_{i=1}^p \bar{\varepsilon}_{ti} + 2\sqrt{\varepsilon_{to}^2 + \sum_{i=1}^p \varepsilon_{ti}^2 + \varepsilon_{te}^2} \dots\dots\dots (1)$$

$$\varepsilon_{tl} = \bar{\varepsilon}_{to} + \sum_{i=1}^p \bar{\varepsilon}_{ti} - 2\sqrt{\varepsilon_{to}^2 + \sum_{i=1}^p \varepsilon_{ti}^2 + \varepsilon_{te}^2} \dots\dots\dots (2)$$

- where,
- ε_{tu} : upper limit of operating error
 - ε_{tl} : lower limit of operating error
 - $\bar{\varepsilon}_{to}$: deviation of specimen
 - ε_{ti} : average value of upper limit and lower limit of partial error: $\frac{\varepsilon_{tui} + \varepsilon_{tli}}{2}$
 - ε_{to} : intrinsic error excluding the deviation of specimen
 - ε_{ti}^2 : variance of partial error: $\frac{(\varepsilon_{tui} - \varepsilon_{tli})^2}{12}$
 - where, ε_{tui} : upper limit of partial error
 - ε_{tli} : lower limit of partial error
 - i : subscript to each partial error
 - p : number of partial errors
 - ε_{te} : standard deviation of dispersion in measured values

5.3 Supplementary explanation on tests

The measurement at different pulse widths shall be treated independently, and shall not be included in partial error. The duration of measurement shall be such that the noise is sufficiently suppressed by averaging process.

6 Distance accuracy test

6.1 Outline of distance accuracy test

The factor of error which determines the accuracy of distance consists of the intrinsic error of specimen and the partial errors due to temperature dependent characteristic

and distance dependent characteristic in the partial error tests. The overall accuracy of distance is calculated by introducing the intrinsic error and partial error expressed in percent (%) into formulae (1) and (2).

6.2 Intrinsic error test

The test system for intrinsic error test for distance accuracy is shown in figure 1. The test shall be carried out under the standard conditions. In OTDR, the distance is not measurable directly and calculated from the time that is necessary for the back scattered light in optical fiber produced by the optical pulse emergent from OTDR to reach the OTDR. Therefore all the measurements are carried out in time domain.

a) **Equipment** The equipment shall be as follows:

- 1) **Optical source** An optical source, which has the same wavelength as that of specimen and a constant delay time between the output optical pulse and the input electric pulse coming from the pulse generator, shall be used.
- 2) **Optical receiver** An optical receiver, which has sufficiently wide band to allow measurement of the optical pulse width of specimen and a constant delay time between the output electric pulse and the input optical pulse, shall be used.
- 3) **Optical coupler** A coupler which has a function to branch or couple input light.
- 4) **Pulse generator** A pulse generator, which generates pulses of necessary pulse width by utilizing the rise or fall of input pulse as the trigger and has a constant delay time between the input pulse and the output pulse, shall be used.
- 5) **Digital delay generator** A delay generator, which is capable of varying the delay time between the input pulse and the output pulse and which has a guaranteed setting accuracy over the measuring range, shall be used.
- 6) **Optical fiber** The kind of fiber shall be selected from table 1. The length shall be not less than 2 m.
- 7) **Time interval counter** A counter which measures the time interval of input pulses. A counter which has guaranteed setting accuracy over the measuring range shall be used.